NAVAL FACILITIES ENGINEERING SERVICE CENTER
Port Hueneme, California 93043-4370

SITE SPECIFIC REPORT
SSR-2453-SHR

JOINT SEALANT INSPECTION: POOLS 13 AND 17

by

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EXECUTIVE SUMMARY

This report documents the efforts of the Naval Facilities Engineering Service Center (NFESC) in responding to a request by the Assistant Resident Officer in Charge of Construction (Marine Corps Base, Camp Pendleton), to investigate two suspect swimming pool joint sealant failures located at Area #13 and Area #17. On February 10, the pools' joint sealant material was examined and tested by NFESC's materials chemist for the following: A) Visual Examination, B) Shore A Hardness, and C) Chemical Analysis. Both Pool 13 and Pool 17 remained full during the field investigation and, as a result, the visual examination was conducted using scuba gear.

Findings from NFESC's investigation are as follows: 1) The applied sealant is the specified polysulfide sealant, 2) The sealant attained an acceptable level of cure, 3) Sealant surfaces have begun to breakdown (sticky surface layer), 3) Sealant surfaces contain between 2 – 5 % algae growth, 4) The joint below stainless steel gutters contains 15 – 35 % sealant failures, 5) Between 2 to 12 inches of sealant has completely disbonded from deep end joints, 6) Pool 13 has 15 linear feet of exposed backer rod (failed sealant), and 7) 85 % of joints contain insufficient sealant thickness in Pool 13.

Deep end areas with failed sealant and joints with exposed backer rod require immediate attention and subsequent repair. A two-component epoxy putty may be used for temporary sealant repairs (several epoxies cure underwater). At a time determined by the Marine Corps Base, the specification enclosed in Appendix A is to be used for the rework of joints.

TABLE OF CONTENTS

INTRODUCTION

This report documents the efforts of the Naval Facilities Engineering Service Center (NFESC) in responding to a request by the Assistant Resident Officer in Charge of Construction (Marine Corps Base, Camp Pendleton), to investigate two suspect swimming pool joint sealant failures located at Area #13 and Area #17. On February 10, the pools' joint sealant material was examined and tested by NFESC's materials chemist for the following: A) Visual Examination, B) Shore A Hardness, and C) Chemical Analysis. Both Pool 13 and Pool 17 remained full during the field investigation and, as a result, the visual examination was conducted using scuba gear.

BACKGROUND

The pools' joints were reworked approximately 1.5 years ago with a polysulfide sealant. Currently, and based upon appearance, the pools' custodian has questioned the joint sealant's performance and believes the applied sealant will provide a reduced service life.

VISUAL EXAMINATION

POOL 13

The joint sealant in approximately 85 % of joints has between a 1/8" to 3/8" recess below joint surfaces. In general, a sealant recess of 1/8" is acceptable. However, and as a result of insufficient sealant thickness, 15 linear feet of backer rod has become exposed through the sealant (for 1/2" wide joints, a minimum sealant thickness of 1/4" is required). The exposed horizontal sealant surface contains approximately 20 mils of a sticky layer (1 mil = 0.001"). Dirt is adhering to this sticky layer which has facilitated the growth of algae. As such, 2 % of joint surfaces contain algae growth. Approximately 35 % of the sealant applied to the 1/4" wide joint directly below the stainless steel gutter has failed. The sealant failure may be a result of application below manufacturer's recommended minimum thickness of 1/4". In the deep end, there is a 2" section of joint sealant that has disbonded and may be leaking water.

POOL 17

Approximately 15 % of the sealant applied to the 1/4" wide joint directly below the stainless steel gutter has failed. In the deep end, 12 inches of joint sealant material has disbonded (area represents several sections) which may be leaking water. The joint sealant's surface contains approximately 15 mils of a sticky layer which contains approximately 5 % algae growth.

SHORE A HARDNESS

Shore A Hardness testing was conducted on one sealant sample per pool. The Shore A scale ranges from 0 to 100 and runs from soft/flexible (low numbers) to dense/rigid materials (high numbers). A properly applied and cured polysulfide sealant exhibits a Shore A Hardness reading of 25 ± 5. The sealant in each pool has a Shore A Hardness value of 25 ± 5. Shore A Hardness results suggest that the polysulfide sealant was properly mixed and attained an acceptable level of cure.

CHEMICAL ANALYSIS

One sealant sample per pool was chemically analyzed using a Fourier Transform Infrared Spectrometer. Results indicate that the joint sealant material applied to both pools is the specified joint sealant. Furthermore, there were no apparent sealant abnormalities identified within the spectral printouts.

DISCUSSION

In areas where the sealant has either completely failed or has failed and exposed backer rod, water may be leaking through the pool. When water leaks through a pool, soil behind the pool's concrete is displaced and voids may be created. These voids cannot support the pool's concrete shell and, under the right circumstances, may cause pool cracking. Therefore, in order to prevent future structural pool repairs, areas with failed sealant require immediate attention and subsequent repair.

In general, polysulfide sealants exhibit poor performance when subjected to a combination of chlorine and sunlight. Chlorine causes polysulfides to chalk and sunlight exacerbates this effect. Extreme chalking is produced when polysulfide sealants are exposed to high levels of chlorine specifically during "Pool Shocking". The combined effects from chlorine, sunlight, and "Pool Shocking" treatments have contributed to the breakdown of the applied polysulfide sealant. The polysulfide's sticky surface layer is a result of the above combined effects.

Using various concentrations of liquid bleach (chlorine equivalent), NFESC has performed immersion testing on three types of pool sealants. Results indicate that urethane sealants should outperform polysulfide sealants when applied to swimming pool joints.

FINDINGS

- The applied sealant is the specified polysulfide sealant.
- The sealant attained an acceptable level of cure.
- Sealant surfaces have begun to breakdown (sticky surface layer).
- Sealant surfaces contain between 2 – 5 % algae growth.
- The joint below stainless steel gutters contains 15 – 35 % sealant failures.
- Between 2 to 12 inches of sealant has completely disbonded from deep end joints.
- Pool 13 has 15 linear feet of exposed backer rod.
- 85 % of joints contain insufficient sealant thickness in Pool 13.

RECOMMENDATIONS

Deep end areas with failed sealant and joints with exposed backer rod require immediate attention and subsequent repair. A two-component epoxy putty may be used for temporary sealant repairs (several epoxies cure underwater). At a time determined by the Marine Corps Base, the specification enclosed in Appendix A is to be used for the rework of joints.

APPENDIX A

SWIMMING POOL SEALANT SPECIFICATION

PART 1 GENERAL

1.1 References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 412 1998 Test Method for Vulcanized Rubber and Thermoplastic Rubber and Thermoplastic Elastomers - Tension

ASTM D 638 1996 Test Method for Tensile Properties of Plastics

ASTM D 2240 1997 Test Method for Rubber Property-Durometer Hardness

ASTM D 4541 1995 Test Method for the Pull-off Strength of Coatings Using Portable Adhesion Testers

1.2 Submittals

All submittals shall be submitted to the Government for approval and records.

a. Single Component Sealant Primer
b. Single Component Sealant
c. Material Certificates (Section 1.2.2)
d. Contractor Qualifications (Section 1.2.3a)
e. Sealant System Performance (Section 1.2.3b)
f. Warranty (Section 1.3)

1.2.1 Instruction

For materials a. – b., submit formulator's printed instructions to include brand name, catalog numbers, and name of manufacturer. Include in the instructions (if applicable) date material was manufactured, shelf-life, detailed mixing and application procedures, quantity of material to be used on job, minimum and maximum application temperatures, and curing procedures. Include copies of Material Safety Data Sheets (MSDS) for all materials to be used at the job site. The sealant and sealant primer shall be manufactured by one material vendor.

1.2.2 Certificates

a. *Single Component Sealant Primer*

Submit certified conformance to the requirements setforth in Section 2.1.1.

b. *Single Component Sealant*

Submit certified conformance to the requirements setforth in Section 2.2.1.

1.2.3 Statements

a. Contractor Qualifications

Minimum requirements for installation contractor are as follows: Installation contractor shall have completed three or more jobs within the past two years applying the materials listed in Section 1.2.1 (a – b) exclusively to concrete surfaces in which the total area exceeds 7,000 linear feet. Contractor shall submit documentation listing location of work, point of contact

at job site, total linear footage of applied materials, listing of both materials and equipment used, and validation from sealant manufacturer documenting quantity of materials purchased per job for work totaling 7,000 linear feet and within the past two-years. Customers referenced by contractor shall be contacted by Government to confirm contractor's work is acceptable.

b. Sealant System Performance

The manufacturer of the sealant shall submit literature documenting the past performance of the sealant system's use in exterior swimming pools. Minimum requirements are two or more exterior swimming pools with joint work totaling 3,000 linear feet whereby the sealant system has performed for two years with less than 1 % combined sealant failures and defects (including algae growth). Sealant manufacturer shall list location of swimming pools, total linear feet of sealant applied per pool, point of contact at pool, date sealant system was applied, and the name of the installed sealant material. Government shall contact each pool to confirm performance of sealant system.

1.3 Warranty: Installation and Materials

There shall be 0 % sealant failures within one year. Within the warranty period, all sealant material that is swollen, cracked, chalking, contains algae growth, or has disbonded shall be removed and reinstalled at the expense of installation contractor.

1.4 Materials: Condition, Storage, Disposal

Materials on site shall be inspected for damage prior to use. Packaged materials in dented, rusty, or leaking containers and, in addition, materials with an expired shelf life shall be returned to manufacturer. Packaged materials shall be unloaded and stored out of sun and weather, preferably in air-conditioned spaces. All unused material, whether in its' cured or uncured state, shall be removed from the job site by contractor.

1.5 Safety

Throughout all phases of work, contractor shall follow the requirements of the Occupational Safety and Health Administration (OSHA) and safety procedures as recommended by the material manufacturers. Safety procedures may include employing the use of impervious clothing, gloves, face shields, respirators, and ear plugs. Prior to use and per material, contractor shall understand the information contained in Material Safety Data Sheets (MSDS).

PART 2 PRODUCTS

2.1 Single Component Moisture-cured Urethane Sealant Primer

Single component, moisture-cured urethane primer for use in priming joint walls prior to the application of joint sealants.

2.1.1 Moisture-cured Urethane Primer

The single component, moisture-cured urethane primer shall be formulated to exhibit the following properties as listed in Table 1.

Table 1: Properties of Moisture-cured Urethane Primer

Resin System	Moisture-cured Aromatic Urethane
Percent Volume Solids	45 – 80 %
Color	Clear to Amber
Immersion in Pool Water	1 year: Excellent[1]
Chemical Resistance to Sodium Hypochlorite	0.05 % Solution: 168 Hours, Excellent[1]
Bond Strength to Concrete (ASTM D 4541)	≥ 400 psi

[1]After immersion and 4 hours of drying, the primer shall not exhibit any blistering, softening, or other coating defects.

2.2 Single Component Moisture-cured Urethane Sealant

Single component, urethane sealant formulated for immersion service and capable of withstanding ± 25 % joint movement. A non-sagging formulation shall be used on vertical joints whereas a self-leveling formulation shall be used on horizontal joints.

2.2.1 Sealant

The single component sealant shall be formulated to exhibit the following properties as listed in Table 2.

Table 2: Properties of Sealant

Sealant System	Moisture-cured Urethane
Percent Volume Solids	≥ 90 %
Vertical Surfaces	Non-sagging sealant
Horizontal Surfaces	Self-leveling sealant
Immersion in Pool Water	1 year: Excellent[1]
Chemical Resistance to Sodium Hypochlorite	0.05 % Solution: 168 Hours, Excellent[1]
Hardness Shore A (ASTM-D-2240)	20 – 30
Tensile Strength (ASTM-D-412)	150 – 200 psi
Percent Elongation (ASTM-D-638)	≥ 500 %
Bond to Concrete	≥ 130 psi

[1]After immersion and 4 hours of drying, the sealant shall not exhibit any swelling, softening, disbonding, chalking or other sealant defects.

PART 3 EXECUTION

"The following procedures have been presented in the order in which the work shall proceed starting with Section 3.1."

3.1 Removal of Material in Joints

Remove 100 % of the existing material in all joints including material bonded to joint walls and base. Remove sand and dirt within joints to a depth of 1" (one inch). Rigid material may require the use of saw cutting equipment to remove. Saw Cutting equipment shall be capable of producing straight lines with sporadic joint spalls less than 1/16".

3.2 Remove Algae and Biological Growth

Remove 100 % of algae and biological growth within joints and up to three inches adjacent joint surfaces. A solution of one part household bleach (5 % sodium hypochlorite) to three parts potable water may be used to remove algae and biological growth. Scrub surfaces with

above solution using firm-bristled nylon brushes. Before solution dries, thoroughly rinse solution with potable water until the rinse water is at a pH between 6.5 to 8.

3.3 Surface Preparation of Joint Walls

Lightly wet joint surfaces with potable water and apply a 5 – 10 % solution of Hydrochloric Acid (Muriatic Acid) to the above surfaces. Application of the acid solution will produce a mild stream of bubbles when reacting with concrete. If either no bubbles or a violent stream of bubbles is observed, then the acid solution requires adjusting. Approximately 15 minutes following the application of the acid solution, remove solution by rinsing with potable water until rinse water is between a pH of 6 to 7.5. Concentrated hydrochloric acid will require dilution with potable water *(always add acid to water and not water to acid).* The acid solution will remove efflorescence, hard water deposits, scaling, and open up the concrete to promote the adhesion of materials. Resulting surfaces shall appear visually clean and free of noticeable contaminants.

3.4 Material Application

Allow joints to air-dry for a minimum of five days after cleaning and prior to the application materials. For each day of rain, a minimum of 2 - 3 additional days of drying is required. If excess water is observed at a joint's base, remove water using sponges or other appropriate devices. If water continues to pool at the base of joints following the five days of drying, then additional materials and procedures above and beyond the specification are required (for example, the use of a water reactive foam at the base of horizontal joints may prevent water migration). After the five days of drying, remove all dirt and dust from within joints.

3.4.1 Temperature and Humidity Requirements

During all material operations, relative humidity shall be below 80 % whereby concrete and ambient air temperatures shall be between 55°F to 90°F and, in addition, a minimum of 5°F above the dew point temperature. If temperatures and humidity exceed the above ranges, then work shall stop until either acceptable temperatures and humidity or material manufacturer approves application under existing conditions.

3.4.2 Mixing and Application of Materials

Mix and apply all materials in accordance to manufacturer's requirements. It is recommended that the sealant primer and sealant be applied in the late afternoon when both the air and concrete temperatures are decreasing. This practice promotes sealant adhesion and reduces disbonding from moisture vapor trapped within the concrete. It is recommended that a representative from the sealant manufacturer be on site to view both the mixing and application of their material.

3.5 Application of Sealant

Inspect joints for the presence of algae and unremoved sealant. Joint surfaces shall be 100 % free of sealant and biological growth. Sweep and vacuum up residual dust from within joints. A non-sagging formulation shall be used on vertical joints whereas a self-leveling formulation shall be used on horizontal joints.

3.5.1 Install Bondbreaker

Install, using a backer rod tool, round closed cell polyethylene backer rod into joints. Backer rod shall be a minimum of 1/8" larger diameter than the width of the joint. Backer rod shall

fit tight between joint walls (30 % compression) with a minimum depth of 3/8" below surface of joint. For 1/2", 3/8", and 1/4" wide joints use a minimum depth of 3/8" above backer rod (3/8" below joint surface to highest point on backer rod). For joint widths greater than 3/4" but less than 2", a maximum joint depth of 5/8" below joint surface shall be used (joints greater than 2" in width require special treatment). All backer rod that is installed using either the incorrect size (loose fit) or at the incorrect depth shall be removed and reinstalled. If the correct joint depth cannot be attained using backer rod, bond breaker tape with an adhesive backing may be used. Resulting tape application shall cover each joint's horizontal base and span its' total length. Bond breaker tape shall contain a thickness less than or equal to 6 mils. The use of sand as a bond breaker is not recommended. Following the installation of backer rod, apply painter's tape to both sides of joints to protect adjacent surfaces from sealant.

3.5.2 Sealant Application

Mix and apply the primer specified in Section 2.1 to joints. Approximately 30 to 40 minutes following priming, apply the sealant specified in Section 2.2 to primed joints. The primer shall be in a tacky state during the application of sealant. If the primer cures to a tack-free state prior to the application sealant, additional priming of joint surfaces is required. Resulting sealant finish shall exhibit either a slight recess (1/32" below the surface of each joint) or remain flush with joint walls. All sealant which cures greater than flush shall be removed and reapplied by contractor at contractor's expense. Immediately following sealant application, remove painter's tape and sealant drips from pool surfaces.

3.6 Curing

Prior to filling the pool, all applied material shall cure in accordance to manufacturer's requirements. Improperly cured material shall be removed and reapplied by contractor at contractor's expense. It is recommended that a material representative sign off on the contractor's finished product.

3.7 Final Cleanup

Following completion of work, remove debris, equipment, and materials from the site. Remove temporary connections to Government furnished water and electrical services. Restore existing facilities in and around the work areas to their original condition.

PART 4 QUALITY CONTROL

4.1 Inspect Surface Preparation and Application of Bond Breaker

Prior to the application of sealant, confirm compliance to Sections 3.1, 3.2, and 3.3. In addition, confirm compliance to Section 3.5.1.

4.2 Inspect Sealant Application

Confirm compliance to Section 3.5.2. Seventy-two hours following sealant application, determine sealant's cure using a Shore A Durometer. Sealant shall cure to a Shore A value between 20 to 35. If cured sealant exhibits values either above (35) or below (20), sealant does not meet the requirements of the specification and shall be removed and reinstalled at contractor's expense.